

Aerial Dispersion of DDT for the Control of the Mountain Pine
Beetle and the Coincidental Effects Upon General Insect Populations,
Teton National Forest, 1947

Plans were made in 1947 by Dr. N. D. Wygant, Division of Forest Insect Investigations, to treat with DDT a number of experimental plots in forests having pine trees infested with the mountain pine beetle, Dendroctonus monticulae Hopk. For several years this insect has occurred in epidemic proportions, particularly in lodgepole pine in Idaho and Wyoming. Since this bark beetle is not easily and cheaply controlled by felling and hand spraying infested trees with an oil spray, it was proposed to test the practicability of spraying infested forests with an oil solution of DDT by airplane. Experience suggested it would be necessary to use a heavy dosage and also that there might be some advantage in dividing certain of the heavy dosages into 2 applications made several weeks apart. Accordingly, the divided dosages were applied to four study areas in the Teton National Forest near Wilson, Wyoming, whereas the single application of a heavy dosage was made against the black hills beetle in the Black Hills National Forest.

It was realized that larger animals might be affected by these heavy applications and several scientists of the U. S. Fish and Wildlife Service were invited to participate in the study. Dr. W. Hosley and Mr. Lowell Adams studied the mammals, Mr. D. Johnston the birds, and Mr. M. Hanivan, the fish and fish-food organisms. Appraisals of the effects of the sprays on the bark beetle by field surveys were made by Mr. T. T. Terrell, Division of Forest Insect Investigations, and Mr. R. Newsomer, Forest Service, whereas the effects on local populations of the bark beetle and general insect populations were followed by the writer.

Methods

The areas to be treated on the Teton National Forest were selected by Mr. Terrell, and Mr. Newsomer, who also supervised the aerial spray project. The forest composition of the plots varied some but they all contained large numbers of infested lodgepole pine, many of which had been killed by or were infested with the mountain pine beetle. Each plot was mapped and cruise lines were established that would be followed later to ascertain the degree of bark beetle control attributable to the sprays.

The size of the plots, dates treated, and dosages are given in Table 1. It was proposed to put on the first spray just after beetle emergence had started and this was perfectly timed and the initial applications were made on July 22 and 23. Inasmuch as the first sprays were not effective in controlling the bark beetle, the date of the second spray was advanced and put on about one week later.

Table 1.--Schedule of DDT Sprays for Plots 1-4, Teton National Forest, 1947.

Area	Acres	1st Spray		2nd Spray		Total Lbs.: DDT/Acre
		Date	Lbs. DDT/Acre	Date	Lbs. DDT/Acre	
1	194	7/25	3-3/4	7/31	3-3/4	7-1/2
2	143	7/22	2-1/2	7/30	2-1/2	5
3	56	7/22	2-1/2	7/30	2-1/2	5
4	84	7/22	2-1/2	7/30	2-1/2	5
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The spray applications were made by a pilot associated with the Central Aircraft Co., Yakima, Washington. The contractor used a Stinson plane-- 325 HP, 150 gallons spray capacity, and a flow rate of one gallon per acre with a swath width of 175 feet. Although the country was mountainous the pilot flew the plane 100 feet or less above the tree canopy.

The nature of the DDT formulation used in these experiments is shown in Table 2. To ascertain the amount of DDT actually reaching the boles of the trees and also the ground in open sites, filter papers were put out to catch the deposit. A chemical analyses of these papers was made later.

Table 2.--Spray Formulation Used for Mountain Pine Beetle Tests.

Ingredients	Formulation for 1/2	Formulation for 1/2
	2-1/2 lbs. DDT/Acre	3-3/4 lbs. DDT/Acre
DDT	1.25 lbs./gal.	1.875 lbs./gal.
Velsicol AR-50	.52 gal.	.78 gal.
No. 2 fuel oil	.48 gal.	.22 gal.
1/2 gallons per acre sprayed on each area in 2 flights on each of 2 spray dates.		

Several methods were used to determine fluctuations in insect populations in areas 1 and 3, collections being made in each and in a comparable check area both before and after spraying. A three by three-foot cloth was placed between and nailed to two logs to serve as a tray to catch insects affected by the spray. These trays were distributed either at 1 or 2-chain intervals along a cruise line running through the middle

of the plot. Sheets or trays made from large grain sacks were placed around many lodgepole pine trees, both infested trees containing callow adults and trees that were recently attacked, to trap mountain pine beetle adults that might be killed by the spray. To determine if the spray deposited on the boles of the trees was sufficient to kill beetles attracted to them, before they could complete gallery formation and raise brood, all new entrance tunnels were marked daily on a two-foot length of the bole. Sticky trap boards, 4 by 8 inches in size, and covered with a waterproof substance which remained sticky, were hung at each tray station. Although these boards proved ineffective in trapping the mountain pine beetle, which is adept at crawling through pine pitch, many insects of diverse orders were caught on them. Other collections were taken by means of a heavy sweep net.

Weather Conditions and Spray Coverage

Good weather prevailed on the spray days and what appeared to be a uniform spray deposit was obtained. A stream in area 3 was thoroughly covered as shown by an oil film on the surface of the water. Beneath the trees and in the open in plots 1 and 3 there was considerable spray injury to plants which also indicated good distribution of the spray. An analyses of the DDT spray deposit on filter papers in different locations, on the other hand, showed that the amounts of DDT reaching the ground even in open sites was highly variable (Table 3). The spray damage was noticeable only on strawberry, cinquefoil, wild geranium, fireweed, and other understory plants, but it is likely that foliar damage to pine trees will show up later.

Effects of DDT Sprayings on Insects in Area 1

This area is located about 6 miles south of Wilson, Wyoming where the elevation is over 8,000 feet. It is fairly well stocked with lodgepole pine, much of which is infested with the mountain pine beetle, interspersed with patches of aspen. The undergrowth near the middle of the area consisted mostly of pine grass (Calamagrostis rubensens) intermixed with wild rose (Rosa sp.), wild geranium (Geranium viscosissimum) paint-brush (Castilleja sp.), and lupine (Lupinus sp.). The check area located about 2 miles northwest of area 1 was similar ecologically.

Soon after the first spray application of 3.75 pounds of DDT per acre was made, large numbers of insects of diverse groups were killed by the spray (table 4). Springtails and flies were present in greatest numbers at the time of spraying. Although the mountain pine beetle was emerging in numbers in the area and attacking new trees, not a single beetle was found on the trays. The residual effect of the DDT was marked as indicated by the lesser numbers of insects found on the trays after the second application about 1 week later. Only a few insects were collected from the trays in the check area.

Table 3.--Summary of DDT spray deposits on filter papers placed in different locations in areas 1 and 3, Teton National Forest, 1947.

		Area 1									
No. of	Location of filter papers	July 23		July 31				July 23 & 31			
filter		Pounds DDT per acre									
papers		Aver.:	Min.:	Max.:	Aver.:	Min.:	Max.:	Aver.:	Min.:	Max.:	
6	Open sites, 5 chains apart through center of area.	0.28	0.11	0.56	0.82	0.32	2.29	1.10	0.50	2.29	
32	Four filter papers pinned vertically at cardinal points, 7 feet from ground, on boles of 8 trees, 5 chains apart through center of area.	0.20	0.06	0.45	0.18	0.05	0.29	0.38	0.08	0.73	
		Area 3									
		July 22		July 30				July 22 & 30			
17	Open sites, 2.5 chains apart, along stream bank.	0.54	0.12	1.13	0.30	0.11	1.24	0.84	0.28	1.45	
8	Open sites, 1 chain apart through center of area.	0.35	0.20	0.55	0.46	0.10	0.83	0.81	0.47	1.24	
8	Four filter papers pinned vertically at cardinal points, 7 feet from ground, on boles of 2 trees in center of area.	0.12	0.09	0.15	0.16	0.03	0.32	0.30	0.13	0.45	

1/ Chemical analyses made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

Table 4.--Total numbers of invertebrates collected in 9 trays each time area 1 was sprayed with DDT in 1947.

Invertebrate	July 23	July 31
Collembola	273	15
Chrysopidae	21	0
Ephemeroptera	12	24
Miridae	51	3
Psyllidae	24	4
Coleoptera	11	1
<u>D. monticolae</u>	0	0
Trichoptera	9	2
Lepidoptera (larvae)	44	1
<u>Rucculatrix</u> sp.	44	2
Diptera	329	76
Hymenoptera	25	6
Other insects	5	0
Araneae	24	12
Totals	572	146

Daily observations before, during, and after the spraying failed to show any significant differences between the numbers of mountain pine beetles collected on sheets placed around old and newly infested trees in the sprayed area compared with those in the check area. Only a few beetles were collected--those pitched out as a result of unsuccessful attack in the new trees. Two pairs of beetles were observed to alight on a green tree and to crawl from 10 to 19 inches in approximately one-half hour before starting gallery formation. This observation establishes the fact that the adults crawl over the bark on the bole and hence would have considerable opportunity of coming in contact with an insecticide distributed there. The ineffectiveness of the two airplane applications of DDT made within one week--total delivered dosage of 7.5 pounds of DDT per acre--in preventing new attacks by this bark beetle is clearly illustrated by the data presented in table 5. This poor showing may be attributed to the small and highly variable amount of DDT deposited on the boles of the trees (table 3.).

Sweeping and sticky trap board collections made about a week before and a week after the last spray application showed almost a 90 percent reduction in the total invertebrate population (tables 6 and 7). Groups affected most were the Diptera, Lepidoptera and Hymenoptera, and also the exposed immature stages of several other orders of insects. An aspen leaf miner (Rucculatrix sp.) was emerging at the time of the first spray application and appeared to be decimated by it. Several species of ants were present in numbers after both sprayings.

Table 5.--Total numbers of new attacks made by Dendroctonus monticolae in sample areas on lodgepole pine trees following airplane applications of DDT in Area 1 in 1947.

Tree no.	d.b.h.	Date									
		7/24 ^{1/}	7/25	7/26	7/28	7/29	7/30	7/31 ^{2/}	8/1	8/4	8/5
11	10	25	2	0	2	0	0	3	0	2	0
12	9	12	4	4	11	4	3	2	3	3	0
13	8	21	2	0	1	1	1	0	0	1	0
14	10	1	6	0	2	2	1	0	0	1	0
15	13	--	39	2	3	2	2	1	0	7	1
16	12	--	38	6	9	3	3	1	0	12	0
17	13	--	19	2	20	7	0	0	1	6	1
18	8	--	4	2	0	0	0	2	0	0	0
19	14	--	17	5	22	5	5	1	1	5	0
20	15	--	44	3	8	6	3	5	1	12	3
21	13	--	5	4	4	6	0	2	1	8	1
22	12	--	2	0	6	15	4	11	0	2	1
23	11	--	3	0	1	0	0	0	0	0	0
24	10	--	16	1	2	1	0	1	0	2	0
25	14	--	35	3	2	2	0	2	0	4	0
26	16	--	45	1	2	5	0	6	0	4	0
27	14	--	--	--	18	7	3	2	2	2	1
28	15	--	--	--	11	6	1	3	8	18	2
29	12	--	--	--	--	--	--	--	3	1	0
30	9	--	--	--	--	--	--	--	11	3	1
100	10	--	--	--	3	9	2	3	2	5	1
101	9	--	--	--	1	1	0	1	0	0	0
102	9	--	--	--	18	12	5	3	3	8	0
103	8	--	--	--	11	5	3	0	4	3	1
104	11	--	--	--	3	15	0	3	17	15	3
105	10	--	--	--	--	13	2	5	1	3	0
106	7	--	--	--	--	1	0	0	0	0	0
107	11	--	--	--	--	13	4	1	0	2	0
108	11	--	--	--	--	28	2	2	0	3	4
109	12	--	--	--	--	12	6	7	3	15	3
110	11	--	--	--	--	11	1	0	1	0	0

^{1/} Sprayed early on morning of July 23.

^{2/} Sprayed early on morning of July 31.

Table 6.--Total numbers of insects taken on 9 sticky trap boards a week before and a week after area 1 was sprayed with 7.5 pounds of DDT per acre.

Orders	Before Spray		After Spray		Percent reduction
	Check	Area 1	Check	Area 1	
Collembola	1	1	35	66	-
Orthoptera	0	1	0	0	-
Neuroptera	17	13	2	0	-
Ephemeroptera	4	8	1	5	-
Thysanoptera	40	74	62	90	21
Heteroptera	3	30	14	1	30
Homoptera	39	14	87	23	20
Coleoptera	24	25	34	10	72
Trichoptera	0	4	0	1	-
Lepidoptera	17	108	13	2	97
Diptera	872	1583	1337	142	95
Hymenoptera	175	213	234	31	89
Totals	1192	2074	1619	373	88

Table 7.--Total numbers of invertebrates taken in 1/2-hour sweepings 4 days before and 5 days after area 1 was sprayed with 7.5 pounds of DDT per acre.

Invertebrate	Pretreatment		Posttreatment	
	Area 1	Check	Area 1	Check
Thysanoptera	184	111	2	2
Acerididae (nymphs)	8	3	0	0
Heteroptera (nymphs)	197	407	0	97
Miridae	163	173	2	426
Aphidae	24	8	7	6
Psyllidae	30	4	0	0
Cicadellidae	20	8	1	13
Coleoptera (mostly Chrysomelidae)	97	31	4	23
Coccinellidae (larvae)	774	105	0	12
Lepidoptera	24	25	3	5
Lepidoptera (larvae)	45	28	2	45
<i>Bucculatrix</i> sp.	248	0	0	0
Diptera	652	1077	44	419
Hymenoptera	270	297	29	102
Ichneumonidae	32	48	3	15
Braconidae	47	26	2	8
Formicidae	108	57	53	38
Tenthredinidae (larvae)	9	10	0	14
Araneae	106	81	4	77
Totals	3038	2499	156	1302
Percent Reduction			90	

Effects of DDT Spraying on Insects in Area 3

Area 3 is located 11 miles south of Wilson, Wyoming. Parts of it have been cut over leaving a sparse pole stand of lodgepole pine with a ground cover mostly of pine grass.

As in the case of area 1, large numbers of insects were killed shortly after the first spray application. Of over 2,000 specimens collected from sheets put on the ground and enclosing the boles of four lodgepole pine trees, about 25 percent were *Collembola*, 30 percent *Bacculatrix* sp., and 15 percent *Diptera*. *Mirids*, *psyllids*, and many species of lepidopterous larvae were also killed in large numbers. New attacks by the mountain pine beetle in marked sections of trees were followed throughout the spray period. The increase in the number of attacks made after the spraying and the successful egg hatch and larval development that followed both attest to the lack of control resulting from the airplane spraying at a total dosage rate of 5 pounds of DDT per acre (table 8). This dosage did not prevent *Ips* bark beetles from successfully attacking lodgepole pine trees either.

Table 8.—Total numbers of new attacks made by *Dendroctonus monticolae* in sample areas on lodgepole pine trees following airplane applications of DDT in Area 3 in 1947.

		DATE									
		1/					2/				
Tree no.:	d.b.h.:	7/24	7/25	7/28	7/29	7/30	7/31	8/1	8/4	8/5	
5	7	25	1	1	1	2	0	0	0	0	
6	6	21	1	1	1	2	2	4	0	0	
7	7	31	2	5	3	12	2	0	0	0	
11	12	--	--	11	6	11	4	1	4	0	
12	8	--	--	21	9	9	6	0	1	0	
13	12	--	43	40	11	1	3	3	0	0	
14	11	--	1	16	5	7	4	2	9	1	
15	12	51	10	7	4	1	2	1	0	0	
16	7	21	4	2	1	1	1	1	1	0	
18	12	--	--	37	10	7	2	0	0	0	
19	8	--	--	21	2	3	3	0	0	1	
20	11	--	--	--	24	3	0	5	1	1	
21	8	--	--	--	52	3	9	2	1	1	
22	7	--	--	--	20	2	0	1	2	1	
23	7	--	--	--	41	9	8	2	0	0	
24	6	--	--	--	9	1	0	1	1	0	
25	10	--	--	--	38	7	2	0	0	1	
26	8	--	--	--	31	9	2	6	0	0	
27	7	--	--	--	21	10	5	5	2	0	
28	8	--	--	--	3	2	0	0	1	0	
29	10	--	--	--	4	11	14	1	5	2	

1/ Sprayed early on morning of July 22.

2/ Sprayed early on morning of July 30.

Summary and Conclusions

1. The aerial spraying with DDT of two forest areas within a week, at aggregate dosages of 5 and 7.5 pounds of DDT per acre respectively, did not prevent the mountain pine beetle from emerging in numbers and attacking healthy lodgepole pine trees. Eggs laid by females hatched and the resulting larvae appeared to be developing in a normal manner.
2. The ineffectiveness of the spray which was distributed under good weather conditions, for bark beetle control is attributed to the small and variable amounts of DDT reaching the bole of the tree.
3. Both dosages caused a marked burning of foliage of understory plants but no visible damage to lodgepole pine trees.
4. The first spray put on each plot killed most of the insects afield at that time and the residual effect was great enough that far lesser numbers were present and affected by the second spraying 1 week later.
5. Two collection methods used to measure the general invertebrate population present in the area receiving 7.5 pounds of DDT per acre and the population in a check area, both before and after spraying, showed a 90 percent reduction in numbers.
6. Adults of an aspen leaf miner, Bucculatrix sp., were emerging at the time of the spray applications and were apparently eliminated.

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April 23, 1949

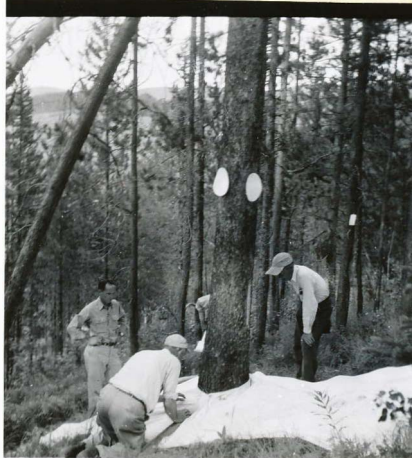


Figure 1.--Sheets fitted around a lodgepole pine tree in area 3 to trap insects affected by an aerial application of DDT. Note position of filter papers on tree to catch spray deposit.



Figure 2.--Large beaver dam upstream on Rock Creek on north side of area 3. Losses of cutthroat trout in this stream were negligible. (Photographs by D. E. Parker)